RK PLAN

OIL CREEK WATERSHED

CRAWFORD, ERIE, VENANGO AND WARREN COUNTIES

PENNSYLVANIA

April 1965

WATERSHED WORK PLAN

OIL CREEK WATERSHED

Crawford, Erie, Warren, and Venango Counties, Pennsylvania

Prepared Under the Authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83d Congress, 68 Stat. 666), as Amended.

Prepared by: Crawford County Soil and Water Conservation District
Crawford County Commissioners
Titusville City Council

With assistance by:

U. S. Department of Agriculture, Soil Conservation Service

U. S. Department of Agriculture, Forest Service

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TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

WATERSHED WORK PLAN

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SUMMARY OF PLAN

The Oil Creek watershed as described in this plan has a drainage area of 112,000 acres (174.4 square miles). Ninety-three percent of this area is in Crawford County with the remaining portion in Erie, Warren, and Venango Counties. The downstream boundary lies just below Titusville immediately above the confluence of Pine Creek with Oil Creek.

The local sponsoring organizations are the Crawford County Soil and Water Conservation District, the Crawford County Commissioners, and Titusville City Council. There are no sponsors in Erie, Warren, or Venango Counties because of the limited acreage of the watershed in those counties and because no works of improvement are needed.

The primary problem in the watershed is floodwater damage at Titusville and vicinity. Other problems include flood damage in the borough of Hydetown and the Mystic Park area, agricultural damages on the flood plain and erosion in the uplands.

Titusville and the surrounding area have suffered periodically from flooding of Oil Creek and its tributaries. Six damaging floods have occurred in the last 40 years. The flood of January 22, 1959 was the most damaging in recent history and caused total damages of $145,486.

A comprehensive plan for the development of the water resources has been prepared by the sponsors with the assistance of the U. S. Soil Conservation Service and the U. S. Forest Service. Other state and federal agencies were consulted including the U. S. Fish and Wildlife Service, U. S. Agricultural Stabilization and Conservation Service, Pennsylvania Fish Commission, Pennsylvania Game Commission, and the Pennsylvania Department of Forests and Waters.

This plan includes conservation land treatment and provides for six single purpose floodwater detention structures.

The work plan proposes installing in a seven-year period a project for protection and development of the watershed at a total installation cost of $3,163,770. The share of this cost to be borne by Public Law 566 is $2,241,580 with the remaining $922,190 borne by local and other funds. The sponsors are also responsible for operation

and maintenance costs.

Land Treatment Measures

The cost for land treatment is estimated to be $811,340 of which $703,840 will be borne by local and other funds. Public Law 566 funds in the amount of $107,500 will be used for accelerating technical assistance and will consist of $88,000 for the use of the Soil Conservation Service and $19,500 for the use of the Forest Service.

Structural Measures

The six single purpose flood prevention structures will control 72.24 square miles of drainage area and provide storage for 10,499 acre feet of floodwater and 491 acre feet of sediment.

The total installation cost of these structures is estimated to be $2,352,430. Of this amount, Public Law 566 will provide $2,134,000 and the sponsors will provide $218,350.

Damages and Benefits

The estimated average annual direct and indirect flood damage without the project is $210,233. The average annual damage remaining with the project installed is $3,311.

The average annual benefit accruing to the structural measures is $209,090. These benefits include $199,990 for floodwater damage reduction, and redevelopment benefits of $9,100.

The ratio of the average annual structural benefits to the estimated average annual cost is 2.6 to 1.0.

Provisions for Financing Construction

Titusville City Council will be responsible for land, easements, and rights-of-way and administration of contracts for structures PA-641, PA-642, PA-643, PA-644, PA-645, and PA-646.

Local political subdivisions have indicated they will provide funds to Titusville City Council for a portion of the land, easements and rights-of-way costs. The land rights' costs, including relocation of utilities and removal of buildings, are $191,850 and the costs of administration of contracts are $26,500.

Operation and Maintenance

Land treatment measures will be maintained by the landowners and operators under agreement with the Crawford County Soil and Water Conservation District.

Titusville City Council will be responsible for operation and maintenance of structures PA-641, PA-642, PA-643, PA-644, PA-645, and PA-646 at an estimated annual cost of $3,300.

DESCRIPTION OF THE WATERSHED

Physical Data

Oil Creek watershed is located in northwestern Pennsylvania. The watershed area as described in this plan is 112,000 acres (174.4 square miles) of which 1,260 acres are in Venango County, 4,330 acres in Erie County, 1,130 acres in Warren County, with the remaining 112,000 acres in Crawford County. The downstream boundary of the watershed is located just below Titusville immediately above the confluence of Pine Creek with the main stem. Oil Creek then flows 15 miles in a southerly direction until it enters the Allegheny River at Oil City, Pennsylvania.

The topography of the watershed is gently rolling with moderately wide flood plains. Elevations range from 1,200 feet at Titusville to approximately 1,900 feet in the northwest portion of the watershed.

Agricultural enterprises are located throughout the watershed with most farming being concentrated in the northwest portion. Titusville, the only sizable community, occupies the lower limits of the Oil Creek flood plain.

Soils and Geology

Oil Creek watershed lies wholly within the glaciated section of the Appalachian Plateau. The topographic surface of the watershed is generally based on the slightly dissected glacial features that form its rolling surface. Deposits from both the Wisconsin and Illinoian glacial advances cover the entire watershed. The drainage pattern has developed on these deposits so that steep valley sides are found in the larger tributaries that have been scoured and filled to a great depth by outwash materials.

The southeastern quarter of the watershed is mantled by the deeply weathered Illinoian inner phase glacial tills. These tills produce soils of the Titusville, Hanover, and Gresham series. Due to drainage imperfections, hardpan layers in the subsoil, acidity, and frequent stoniness, these soils are generally not well suited for crop use. They are suitable for impoundments due to their strength and relatively low permeability.

The remainder of the watershed is mantled by glacial deposits relating to the Cary substage of the Wisconsin glacial advance. The deposits, chiefly terminal and ground moraines, form soils of the Cambridge, Venango, Frenchtown, Erie, Langford, and Ellery series. These soils, with the exception of Langford, are restrictive in agricultural uses due to their acidity and imperfect drainage. They are suitable for impoundments because of their strength and slow permeability.

Frequent fluvio glacial deposits, such as kames, parallel the larger tributaries of the watershed. These are principally sands and gravels from which the Wooster, and Chenango soil series are formed. These soils are well suited for agricultural use. They present some hazards when used for impoundment sites due to their rapid permeability.

Glacial outwash and some recent alluvium are found on flood plains of the larger tributaries. These comprise the Papakating, Holly, Lobdell, and Chagrin soil series. The poorly drained soils have a limited cultural capability. The well drained soils which are protected from overflow have good agricultural potential.

The underlying bedrock is basically sandstone and shale ranging in age from the Devonian Riceville shale to the Pennsylvania Pottsville formation. These are folded into low dip structures which have seen a source of petroleum since the first oil well was drilled at Titusville. Sand and gravel from the kame deposits are abundant in the area. These fluvic glacial features are an excellent source of groundwater.

Water

The headwater streams of Oil Creek have their source in the agricultural lands of southeastern Erie County. Lake Canadohta, located on the western branch of Oil Creek, and Clear Lake, located on the east branch of Oil Creek, are the only sizable lakes in the watershed. The east and west branches of Oil Creek join at Centerville. The only other major tributary is Thompson Creek which empties into Oil Creek at Hydetown. Oil Creek then flows in a southeastern direction to a confluence with Pine Creek below Titusville.

The gradient of the tributary streams averages less than one percent while the gradient of the main stream is less than one-tenth of one percent. Significant areas of marshland are scattered throughout the watershed.

Climatological

Precipitation averages 42 inches annually with about 18 inches falling during the growing season. The yearly temperature averages 48° F with extremes ranging from 30° F below zero to 105° F above. The frost-free growing season averages 110 to 140 days.

Land Use and Cover Conditions

Land use in the watershed is estimated to be 15 percent cropland, 15 percent pasture, 55 percent forest, 10 percent idle, and 5 percent in streams, roads, and towns.

About 55 percent of the watershed is in farmland. The cropland and pasture acreage of 33,600 acres is utilized for general farm crops and forage crops to support the livestock enterprise. The farmlands are generally being used within their capability limitations and there

are no areas requiring critical area treatment. The Conservation Needs Inventory indicates that 85 percent of the cropland is in capability classes I to III. The trend on the upland farms is to convert cropland to hay and improved pasture and to develop a good grassland program.

Land on the flood plain is not being farmed intensively. Most of the flood plain soils are poorly drained and have limited agricultural value. A portion of the flood plain lands on Thompson Creek is restricted in use at the present time because of the flood hazard.

Approximately 55 percent (61,500 acres) of the watershed is in forest cover. Hardwood stands, occupying 92 percent of the area, consist of the northern hardwood, ash-maple-elm, aspen, and red oak types. The remaining eight percent consist of mixed stands of hemlock and hardwoods. Approximately 24 percent of the forest stands are of sawtimber size having more than 1,500 board feet per acre. Forty-eight percent of the timber is in pole-sized stands, largely in the heavy pole category having more than 600 cubic feet per acre. Twenty-four percent of the stands are of seedling and sapling size and the remaining four percent in poorly stocked seedling and sapling stands and nonproductive forest stands.

There are approximately 2,700 acres of state-owned lands under the administration of the Pennsylvania Game Commission. The remainder of the forest land is in private ownership.

Adequate forest fire protection is provided by the Pennsylvania Department of Forests and Waters in cooperation with the U. S. Forest Service under the Clarke-McNary Act.

These lands are well suited for the production of timber products. Under protection and management the improvement of forest hydrologic conditions is expected.

Economic Data

The watershed is rural in character with the largest community, Titusville, located at the lower boundary. The village of Hydetown is also located in the lower portion of the watershed while Centerville and Spartansburg are in the upstream portion.

Total population in the watershed is estimated to be 15,200 with 54 percent living in Titusville.

The industrial activities are concentrated in Titusville. Among the products produced are iron and steel forgings, machine parts, plastics, petroleum products, lumber, and dairy products. Statistics from the Pennsylvania Department of Internal Affairs and a comprehensive plan prepared by the Titusville Planning and Zoning Commission indicate that manufacturing industries in the Titusville area employ approximately 2,800 people, with an annual payroll of $10 million. The annual value of the production and related activities is $35 million.

Titusville also serves as a retail and wholesale trade area for eastern Crawford County and portions of Venango and Warren Counties. Retail sales account for about $18 million annually with more than 1,000 people employed by retail firms.

Crawford County has been certified for assistance under Section 5a of the Area Redevelopment Act of 1961 indicating an unemployment rate above the national average.

There are about 450 farms in the watershed averaging 126 acres in size. The average value per farm and buildings is $13,089. Crawford County ranks 53rd of the 67 counties in the state in this respect according to the Pennsylvania Department of Agriculture. The average value of agricultural production in the county is estimated to be $17,103,000. The county ranks 13th in farm cash receipts, although it is ranked 7th in farm acreage in the state. This indicates that agricultural productivity is lower than the state average.

The agriculture census indicates that more than half of the 2,800 farm operators in the county work off the farm with 46 percent of these working off the farm more than 100 days annually. Income from off-farm work exceeds the value of farm products sold on 53 percent of Crawford County farms.

Most farms are operating as family farm units. Only seven farms hire farm managers. Census figures indicate that family workers compose 80 percent of the farm labor forces. Less than 10 percent of the farms in the county report the use of regular hired workers and only 20 percent of these report the use of more than one hired worker.

The watershed, comprising 16 percent of the county area, represents a cross section of the county's agriculture.

The Crawford County Soil and Water Conservation District has been in operation nine years. In the watershed area, 21 farmers have developed conservation farm plans on 3,700 acres of farmland. Table 1a indicates the type and amount of land treatment measures installed on these farms.

The watershed area lies within the Penn Soil Resource Conservation and Development Project which encompasses an area of 1,518,100 acres of land and includes all of Crawford, Mercer, and Venango Counties, Pennsylvania. The Penn Soil Resource Conservation and Development Project Work Plan developed by the sponsors of the project has been approved by the Secretary of Agriculture. Objectives of the Resource Conservation and Development Work Plan include increasing farm income by development of more efficient operating units, conversion of uneconomic farm units, promoting multiple use of woodlands, increasing woodland financial returns, development of private recreation areas, and development of comprehensive land use plans.

Wildlife resources in the watershed are important and attract both large and small game hunters. Game species include deer, turkey, grouse, rabbits, squirrels, and pheasants. Fur animal species include muskrat, mink, and beaver while water fowl make use of the wooded streams and swamps in the watershed. Fishery resources include warm water species in Canadohta Lake and Clear Lake and the main stem of Oil Creek while the east and west branches of Oil Creek, Thompson Creek, McLaughlin Run, Shirley Run, and Five-Mile Creek support a substantial trout fishery.

The watershed is serviced by a good highway system. Pennsylvania State Routes 8 and 89 traverse the watershed in a north and south direction and State Routes 27 and 77 cross the watershed in an east and west direction. The New York Central and the Pennsylvania Railroads provide freight service to Titusville with the latter also serving Hydetown, Centerville, and Spartansburg.

WATERSHED PROBLEMS

Floodwater Damage

Flooding in the watershed has long been a serious problem. Ten major floods have occurred in the last 100 years with the storm of record occurring in 1892.

The flood of January 22, 1959 has been selected as the key flood for the damage analysis. Its frequency of occurrence is estimated to be 30 years. The key flood was exceeded in magnitude by the floods of 1892, 1913, and 1948. A 100-year frequency flood would cause damages of $7,227,000 and severely damage the business and industrial district in Titusville. Average annual direct damage in the watershed is estimated to be $175,365.

The main damage center is the city of Titusville. The 1959 flood inundated 175 acres and caused damages of $72,477. This damage occurred to more than 100 residences, 30 businesses, 4 industries, 2 public parks, and utilities, roads, and bridges.

The community of Hydetown and the Mystic Park area also suffered appreciable damage from the key storm. Damage in Hydetown was estimated to be $12,324 and affected 16 homes and one commercial establishment. Damage in the Mystic Park area was $50,103 and affected 48 residences and a private park and roads and bridges.

Four hundred and forty acres of agricultural land were affected by the 1959 flood. Flood damage to agricultural buildings is insignificant, with most of the agricultural damage resulting from a reduction in crop and pasture production.

In addition small amounts of damage to rural residences, roads, and bridges occurred throughout other areas of the flood plain.

Indirect Damages

Indirect damages were estimated to be 20 percent of the direct non-agricultural damages and 10 percent of the direct agricultural and sediment damages. These damages include delaying shipments of materials and products, loss of wages to employees, increased costs due to rerouting traffic, interruption of public utilities and similar services.

Sediment Damages

Sediment damage within the watershed is generally light. Flood plains tend to be either steep and narrow, or wide and poorly drained. Infertile overwash generally damaged low value land resulting in a low monetary loss. In areas of significant damage, allowance was made for sediment damage on an individual basis.

Sediment from various sources produces other damages associated with floodwater damage, but because of the difficulty in separating them, this damage was evaluated as part of the total floodwater damage.

Coarse sediment is deposited in channels at several locations throughout the watershed, raising creek bottom elevations and resultant flood stages. Sediment deposition at Titusville does cause channel maintenance problems resulting in frequent channel cleaning. Controlled discharge from the proposed structures will reduce the damage resulting from sedimentation in this area by an estimated 91 percent, resulting in a direct benefit to the project.

Annual sediment production, predominantly derived from sheet erosion, is estimated to be 895 tons per square mile. Total combined average annual sediment yield at the proposed structures is estimated to be five acre feet.

Erosion Damage

Erosion problems in the watershed are not critical. Sheet erosion is noticeable in some cropland areas. Minor gullying has developed along some steep waterways due to undercutting of steep glaciated valley sides.

Streambank erosion occurs to some extent throughout the watershed. This erosion is taking place on low value land so the extent of its damage was not appraised nor considered to be an agricultural damage.

Land Treatment

There are no critical land treatment problems within the watershed. The Conservation Needs Inventory indicates that approximately 27 percent of the cropland and 37 percent of the grassland acreage

has received adequate treatment. Agriculture in the watershed is declining. Census figures indicate the farm acreage has declined 21 percent in the last ten years. Land use adjustment has centered on the retirement of land from crop production. The land being taken out of row crops is being used for the production of forage crops, for livestock enterprises, and planting of trees for Christmas tree production.

Agricultural census figures in Crawford County indicate that during the five years ending in 1959, the acreage of corn grown for grain decreased seven percent and wheat acreage decreased 63 percent while hay acreage increased 4 percent. These figures are also representative of the changes in cropland use in the watershed. These crop adjustments and land use changes are continuing at the same rate. Conservation measures consistent with the land use adjustments taking place are being established by landowners throughout the watershed.

The Agricultural Stabilization and Conservation Service records indicate that an average of $23,200 per year in cost sharing funds has been earned by farmers in the watershed over the last two years.

Problems Relating to Water Management

Water Supply

There are two water supply systems in the watershed. The City of Titusville owns and operates a municipal water system which serves residents and industries within the city limits. The source of supply for this system is a number of wells located on the flood plain of Oil Creek immediately north of the town. City officials have indicated that the water supply from this source is sufficient to meet present needs and future requirements. The only other water supply system in the watershed serves residents in the Canadohta Lake area.

Residents of the smaller villages and rural residents obtain their water supply from wells and springs.

Recreation Needs

Water-oriented recreation opportunities for watershed residents are provided by Canadohta Lake, Clear Lake and areas along Oil Creek. Canadohta Lake, which is highly developed as a summer resort area, has a surface acreage of 169 acres. Many of the summer residents come from outside the watershed. The Pennsylvania Fish Commission stocks and manages the fishery resources of the lake and maintains an area for public parking and provides a boat launching facility.

Clear Lake has a surface area of 64 acres. Its use is limited mainly to residents living in the Spartansburg area. Sugar Lake, 150 acres, 12 miles west of Titusville, and Tamarack Lake, 560 acres, located 25 miles west of the watershed, provide further opportunities for fishing and boating.

The Pennsylvania Fish Commission also stocks trout in 23 miles of Oil Creek and its tributary streams.

The U. S. Fish and Wildlife Service maintains an area of 5,000 acres as a national refuge approximately eight miles west of the Oil Creek watershed. In addition, the Pennsylvania Game Commission owns and manages 2,700 acres of land in the watershed for public hunting.

PROJECTS OF OTHER AGENCIES

The Pennsylvania Department of Forests and Waters carried out a channel improvement project in the Titusville area after the October 1954 storm. The effects of the stream clearance and dike project have been evaluated in the development of the work plan. No other water resource development measures which will affect the proposed program have been built or are planned in the watershed.

BASIS FOR PROJECT FORMULATION

The sponsors desired protection from the key storm throughout the watershed and wanted to develop a program which would minimize the effects of a 100-year frequency storm in the Titusville area. The proposed plan will accomplish these objectives.

The objectives for land treatment and proper land use were also of prime consideration to the sponsors. Crawford County Soil and Water Conservation District has developed a long range district program. The directors' objectives have been and will continue to be desirable land use adjustments and use of the land resources to effect improvement on the economy of the watershed, with emphasis being put on the orderly transition in land use of the land going out of agricultural production, the development of water impoundment areas by private capital, and the encouragement of the establishment of income-producing recreation enterprises based on these water developments. These objectives are spelled out in detail in the Penn Soil Resource Conservation and Development Project Work Plan.

Soil and water conservation district directors have prepared a plan which indicates that they will work closely with farmers and other landowners in the watershed to bring about necessary land use adjustments and conservation treatment as quickly as resources permit. The land treatment portion of the work plan reflects these objectives.

Alternate sites were studied in development of the plan. In addition to the sites proposed in the plan, surveys and cost estimates were developed on four additional sites. The sites discarded could not be justified because of high construction costs and the limited benefits accruing to the structures. The combination of structural sites selected provide the desired protection at the lowest cost of all alternatives studied.

WORKS OF IMPROVEMENT TO BE INSTALLED

Land Treatment Measures

Land treatment measures will be installed for both watershed protection and flood prevention purposes. Land will be used within its capabilities and land treatment measures installed will be in accordance with needs and objectives to be accomplished.

Land treatment measures are the basic element of the watershed project, and were considered as the initial increment for project formulation. Emphasis will be placed on accelerating those measures which significantly effect the reduction of floodwaters and sediment yields.

A program to meet the land treatment needs has been developed as follows:

Open Land

Vegetative measures will be established to improve soil cover conditions and physical characteristics of the soil. This will decrease runoff and erosion, will assist in preventing sediment from filling stream channels and will result in less deposition on the flood plains. These measures include conservation cropping systems, stripcropping, seeding of improved grasses and legumes, and hayland and pasture renovation.

Establishment of diversions, grassed waterways, and terraces will have a measurable effect in reducing peak discharge by slowing runoff and will augment the soil improvement cover measures in reducing erosion damage and sediment yields. Installation of drainage measures on the poorly drained, more level soils will result in beneficial adjustments in land use by permitting retirement of upland soils which have a greater erodibility potential. The establishment of farm ponds will make livestock water more available and permit more intense pasture management which will result in less overgrazing, higher infiltration capacities, and a reduction in the erosion hazard.

The establishment and development of wildlife practices, such as wildlife habitat development, will provide improved cover conditions and will contribute to the perpetuation and expansion of the wildlife resources in the watershed.

The work plan proposes the completion of soil surveys within the watershed. Records indicate that 109,000 acres remain to be mapped. It is estimated that the amount of technical assistance needed to complete the soil mapping in the watershed is 2,700 hours.

Forest Land Measures

To insure proper forest land treatment and maximum watershed protection, forest landowners will be provided technical assistance for tree planting, hydrologic cultural operations, woodland grazing control and skid trail and logging road erosion control. These forestry practices will contribute to improved hydrologic conditions effective in reducing flood peaks, reduction of sedimentation, and in recharging ground water during the winter and spring.

Forest trees, through development of deep root systems, extend the soil zone available for storage of water. Thus during the summer and fall flood season, evapotranspiration removes maximum volumes of water from the soil profile and creates optimum opportunity for the immediate storage of storm precipitation.

The forest cover, which contributes to lowering of water tables through evapotranspiration, also creates accumulations of litter and humus which protect the soil, increase surface infiltration and percolation rates, and increase soil moisture storage capacity, thereby reducing surface runoff contribution to flood flows.

Manipulation of stand composition creates favorable conditions for the maximum production and protection of litter, humus, and forest cover. Control of woodland grazing results in the protection of vegetative cover from browsing and also prevents soil compaction from trampling. Ungrazed forest offers optimum conditions for infiltration trails and logging roads by simple structural measures, reduces runoff velocity and soil erosion is retarded. Stabilization and decreased sedimentation are further attained by sowing forest grasses, and shrub and tree planting.

The Crawford County Soil and Water Conservation District program and the technical assistance programs made available through the district all emphasize the use of the land within its capabilities. The district program places emphasis on the production of forage crops and planting of trees for Christmas tree production with a resultant decrease in acreage of grain crops and will have a beneficial effect on land use adjustments.

Structural Measures

Forty-one percent of the drainage area above Titusville will be controlled by the following sites:

PA-641

This structure will be a single purpose flood prevention dam located on Britton Run, one mile south of Route 77. It will be 43 feet high and 2,300 feet long and will contain 203,000 cubic yards of earth fill. The structure will control 9.04 square miles of drainage area and will store 1,300 acre feet of floodwater (the equivalent of 2.70 inches of runoff)

below the crest of the emergency spillway. It will be designed with a two-stage riser, 42-inch pipe combination principal spillway. The first stage release will be orifice controlled, (maximum flow 136 cubic feet per second) and the 42-inch pipe will control the second stage release for a maximum flow of 230 cubic feet per second. A 370-foot emergency spillway will be excavated in undisturbed ground on the left abutment.

It will be necessary to relocate a township road, electric lines, and telephone lines around the emergency spillway area.

PA-642

This single purpose flood prevention dam will be located on Five-Mile Creek, approximately one mile east of Route 89, in the vicinity of Fish Flats. It will control 7.29 square miles of drainage area and will store 1,092 acre feet of floodwater (the equivalent of 2.81 inches of runoff) below the crest of the emergency spillway. The dam will be 36 feet high, 3,200 feet long and contain 490,000 cubic yards of earth and rock fill. It will be designed with a two-stage riser, 42-inch pipe combination principal spillway. The first stage will be orifice controlled for a maximum release of 110 cubic feet per second while the second stage will be pipe controlled for a maximum release of 223 cubic feet per second. A 180-foot and a 120-foot emergency spillway will be excavated in undisturbed ground and rock in the right and left abutments respectively.

PA-643

PA-643 will be a single purpose flood prevention dam located less than 1,000 feet south of Township Route 639 on McLaughlin Creek, approximately two miles north of Hydetown. The dam will be 45 feet high, 400 feet long and will contain 60,000 cubic yards of earth and rock fill. It will control 8.90 square miles of drainage area and will store 1,101 acre feet of floodwater (the equivalent of 2.32 inches of runoff). A two-stage riser, 42-inch pipe combination principal spillway will be designed with a maximum first-stage release of 150 cubic feet per second and a maximum second-stage release of 232 cubic feet per second. A 150-foot emergency spillway will be cut into rock on the right abutment of the dam.

A section of Township Route 639 will be abandoned.

PA-644

PA-644 will be a single purpose flood prevention dam located on Shirley Run, approximately 1,500 feet east of Route 89, in the vicinity of Cloverdale Corners. It will be 50 feet high, 1,100 feet long and consist of 168,000 cubic yards of earth and rock fill. The structure will control 8.70 square miles of drainage area and will store 1,460 acre feet of floodwater (the equivalent

of 3.14 inches of runoff) below the crest of the emergency spillway. The principal spillway will be designed as a single-stage riser and 36-inch pipe, having a maximum release of 190 cubic feet per second. A 250-foot emergency spillway will be excavated into natural ground and rock on the right abutment of the dam.

It will be necessary to relocate electric lines, anchor telephone lines, protect one set of buildings, and obtain a flooding easement on Township road T992.

PA-645

PA-645, a single purpose flood prevention dam, will be constructed across Oil Creek, approximately one-half mile north of Centerville. It will be 45 feet high, 1,300 feet long, and will be composed of 310,000 cubic yards of earth fill. The dam will control 34.90 square miles of drainage area and will store 5,000 acre feet of floodwater (the equivalent of 2.69 inches of runoff) below the crest of the emergency spillway. The principal spillway will consist of a single-stage riser and a 6-foot by 6-foot conduit combination, with a maximum release of 960 cubic feet per second. A 600-foot emergency spillway will be excavated into natural ground on the right abutment of the dam.

It will be necessary to acquire four sets of buildings and to relocate the electric lines.

PA-646

PA-646 will be a single purpose flood prevention dam, located on Church Run just north of Titusville. It will be 60 feet high, approximately 800 feet long and consist of 185,000 cubic yards of earth and rock fill. The dam will control 3.41 square miles of drainage area and will store 546 acre feet of floodwater (the equivalent of 3.00 inches of runoff) below the crest of the emergency spillway. It will be designed with a single-stage riser, 24-inch pipe combination principal spillway, having a maximum release of 76 cubic feet per second. A 200-foot emergency spillway will be excavated into natural ground and rock on the right abutment of the dam.

It will be necessary to acquire or protect four sets of buildings and to relocate electric and telephone lines. Preliminary studies of the Pennsylvania Department of Highways indicate that Route 89 will be relocated outside of the PA-646 site.

EXPLANATION OF INSTALLATION COSTS

Land Treatment

The unit costs for installation of land treatment measures were based on current costs of materials, equipment and services for similar work.

The cost of technical assistance for the installation of land treatment measures was based upon analysis of expenditures for this type of assistance and soil and water conservation districts' accomplishments for the past several years.

Costs for the installation of forest land treatment measures are based on current costs of supervision, labor, equipment, and materials needed for each measure. Costs of technical assistance are based on actual expenditures and accomplishments of the Pennsylvania Department of Forests and Waters. An analysis of costs against accomplishments was made for each measure to determine unit costs.

Structural Measures

Construction costs for the structural measures were based upon unit prices from recent contracts for comparable work. These estimates were based on a summation of the costs for clearing, grubbing, common excavation, compacted earth fill, drainage material, rock excavation, concrete pipe, seeding and mulching. The total construction cost estimates included 12 percent for contingencies. Installation service costs included estimates for detailed geologic investigations for each site. Other engineering and administrative services were estimated as a percentage of the construction cost based upon records of recent experience for similar work.

Public Law 566 funds will provide all of the flood prevention construction and engineering services' costs. The sponsors will provide all costs of land rights and administration of contracts.

Land acquisition costs and values of the buildings affected by the structures were based on estimates prepared by the sponsors. Relocation costs for electric and telephone utilities were based on estimates prepared jointly by the sponsors and the utilities involved and reviewed by the Soil Conservation Service.

Property survey costs to establish boundaries for land acquisition were based upon records of recent experience for similar work.

The estimated costs for administration of contracts and operation and maintenance were based upon records of these costs from similar projects in the state over the last three years.

The following summarizes the construction schedule and the estimated installation costs:

Year		Structural Measures	Land Treatment	Total
1st	P.L. 566	50,000	16,000	66,000
	Other	50,000	60,000	110,000
	Yearly Total	100,000	76,000	176,000
2nd	P. L. 566	400,000	18,000	418,000
	Other	100,500	80,000	180,500
	Yearly Total	500,500	98,000	598,500
3rd	P. L. 566	400,000	16,000	416,000
	Other	20,000	100,000	120,000
	Yearly Total	420,000	116,000	536,000
4th	P. L. 566	500,000	16,000	516,000
	Other	15,000	110,000	125,000
	Yearly Total	515,000	126,000	641,000
5th	P. L. 566	300,000	16,000	316,000
	Other	15,000	120,000	135,000
	Yearly Total	315,000	136,000	451,000
6th	P. L. 566	350,000	15,000	365,000
	Other	10,000	120,000	130,000
	Yearly Total	360,000	135,000	495,000
7th	P. L. 566	134,080	10,500	144,580
	Other	7,850	113,840	121,690
	Yearly Total	141,930	124,340	266,270
Project)	P. L. 566	2,134,080	107,500	2,241,580
Period)	Other	218,350	703,840	922,190
Totals)	Yearly Total	2,352,430	811,340	3,163,770

EFFECTS OF WORKS OF IMPROVEMENT

Damage from storms of the key flood magnitude will be essentially eliminated. In the main damage area of Titusville, remaining damage from the storm such as occurred on January 22, 1959 will be reduced to $300. The projected 100-year frequency storm at Titusville would be controlled so that the estimated $6,800,000 damage would be reduced by 99 percent.

At the present time the 100-year flood frequency discharge of Oil Creek at Titusville is 20,000 cubic feet per second. After the project is completed the controlled discharge from a 100-year frequency storm at Titusville will be 11,700 cubic feet per second. In the business district of Titusville, with the program in place, the

projected 100-year frequency flood would be reduced by three feet while the 1959 flood would be reduced two feet. The projected 100-year frequency flood without a program would be two and one-half feet deep in the industrial section of Titusville. After the project is completed, the projected 100-year frequency flood would not enter the industrial area. The 175 acres in Titusville which were inundated by the 1959 flood would be completely protected from a recurrence of this flood. (See Figure 3, Flood Frequency Map.)

The projected 100-year flood on Church Run in Titusville will be controlled by the program. Peak discharge of a low-year frequency flood on Church Run will be reduced by 700 cubic feet per second.

Damage in the Mystic Park and Hydetown areas would not be completely eliminated if the January 1959 flood would recur.

In the Mystic Park area, the program will reduce the peak discharge of the 100-year frequency flood from 15,600 cubic feet per second to 8,800 cubic feet per second. The stage of a 100-year flood would be reduced 4.5 feet while the stage of the 1959 key flood will be reduced three feet.

In the Hydetown area the program will reduce the peak discharge of the 100-year frequency flood from 4,800 cubic feet per second to 2,900 cubic feet per second. The stage of a 100-year frequency flood will be reduced 4.5 feet while the stage of the 1959 key flood will be reduced 4.0 feet.

Remaining damages of $3,000 would occur mainly to low elevation summer cottages which are located in the area immediately below Mystic Park. At this point, the flood plain narrows and the cottages are located within twenty feet of the streambank.

A section of the residential and business district of Titusville which is located on the flood plain has been approved for redevelopment under the Urban Renewal Administration Program. Redevelopment will greatly increase capital investment in this area and makes it more imperative that a flood protection program be put into effect.

Agricultural lands located above Titusville and on the Thompson Creek flood plain will receive substantial protection from the project. Land treatment measures planned for the watershed will substantially reduce sediment and erosion damages. The protection afforded to the agricultural flood plain will increase the efficiency of the farms affected and permit more proper land use. Net returns are expected to increase as a direct result of the reduction of flood damage and because of more efficient operations which will permit reduction in both fixed and variable costs.

PROJECT BENEFITS

The total average annual project benefit accruing to the structural measures is $209,090. The average annual floodwater damage without the project is estimated to be $210,233. The average annual damage is reduced to $3,311 with the project installed. Average annual flood prevention benefits are $216,023.

As indicated in Table 5, flood prevention benefits are 7 percent residential, 6 percent commercial, and 85 percent industrial, with the remaining benefits accruing to parks, roads and bridges, and agricultural lands.

Benefits realized from the recreational use of the sediment pools were not evaluated on a monetary basis. Additional benefits to fish and wildlife will result from an increase in habitat, and an increase in productivity of existing habitat through the establishment of land treatment measures and land use adjustments. These benefits were not included in the evaluation.

The proposed forest land treatment measures will improve the hydrologic conditions and productivity of the forest land. This will reduce sediment and retard runoff. Good management and continued fire protection will increase the productivity of the forest land.

Crawford County has been designated as a 5a county under the Area Redevelopment Act. Benefits resulting from increased labor resources required for project construction and operation and maintenance have been assigned. The evaluation of these benefits was limited to the first 20-year period of the project. The redevelopment benefits stemming from increased labor used are $9,100. Because of chronic unemployment of labor resources in the area, the added unit of employment is significant.

Secondary benefits were not evaluated in monetary terms for justification of the project.

Non-monetary benefits will also accrue from the knowledge that businesses, industries, and homes are protected from flood loss and the peace of mind this affords. This fact will increase the spirit and effectiveness of all activities in the watershed.

COMPARISON OF BENEFITS AND COSTS

The structural measures described in this work plan are economically justified.

The ratio of the primary average annual structural benefits ($209,090) to the estimated average annual cost ($79,160) is 2.6 to 1.0. Table 6 shows a comparison of annual costs to annual benefits.

PROJECT INSTALLATION

The installation period for accomplishing the plan will be seven years. The order of priority recommended for installation is PA-645, PA-646, PA-643, PA-641, PA-642, and PA-644.

The crawford County Soil and Water Conservation District, will be responsible for working with landowners and operators to carry out the land treatment measures to be established within the next seven years. The Soil and Water Conservation District, with the assistance of the Soil Conservation Service, will assist landowners and operators co-operating with the district in the preparation and application of farm conservation plans.

Fifty percent of the farmland in the drainage area above each flood retarding structure will be under cooperative agreement with the Soil and Water Conservation District before construction of the dams can be initiated. Technical assistance to the District cooperators will be accelerated under the Public Law 566 program as set forth in this work plan. Provisions for carrying out this accelerated program will be included in the annual work plans of the Soil and Water Conservation District.

The forest land treatment measures will be installed by the landowners and operators with technical assistance furnished by the Pennsylvania Department of Forests and Waters in cooperation with the U. S. Forest Service.

The Crawford County Soil and Water Conservation District has agreed that an intensive program of assisting farmers in the drainage areas above the structural works of improvement has the highest priority.

The annual work plans will include goals for the establishment of land treatment practices. Land use adjustments and other conservation activities set forth in the work plan will be met within the program period.

The Agricultural Extension Service of the Pennsylvania State University through the County Agricultural Extension Agents, will assist the Soil and Water Conservation District in developing and carrying out an information and education program to stimulate interest in watershed activities.

Titusville City Council will be responsible for the acquisition of land rights, including highway and utility relocations, for sites PA-641, PA-642, PA-643, PA-644, PA-645, and PA-646. Local political subdivisions have indicated that they will provide funds to the Titusville City Council for the acquisition of land rights. The amount of funds to be provided by the various political subdivisions is the responsibility of the Titusville City Council and the political subdivisions concerned.

The titusville City Council will acquire and provide assurance that land owners or water users acquire such water rights as may be needed in the installation and operation of structures PA-641, PA-642, PA-643, PA-644, PA-645, and PA-646, and will be responsible for securing the necessary permits from the Water and Power Resources Board of the Pennsylvania Department of Forests and Waters for these structures.

The Titusville City Council will be responsible for the administration of contracts for structures PA-641, PA-642, PA-643, PA-644, PA-645, and PA-646.

The Titusville City Council has the right of eminent domain and will exercise it if necessary for the acquisition of land, easements and rights-of-way.

FINANCING PROJECT INSTALLATION

Federal assistance for carrying out the works of improvement on non-Federal land as described in this work plan will be provided under the authority of the Watershed Protection and Flood Prevention Act, Public Law 566, (83d Congress, 68 Stat. 666), as amended.

The Soil and Water Conservation Loan Program of the Farmers Home Administration is available to all eligible farmers in the watershed.

The Crawford County Agricultural Stabilization and Conservation Committee in administering the Agricultural Conservation Program Service will assist in the land treatment program through cost sharing. It is estimated that $40,000 of Agricultural Conservation Program Service cost sharing funds will be needed annually for this purpose. The actual determination of how much assistance can be provided will be made on an annual basis and will be influenced by the needs and desires of the landowners. The Crawford County Soil and Water Conservation District, the County Agricultural Stabilization and Conservation Committee, the Pennsylvania Department of Forests and Waters, the U. S. Forest Service, and the Soil Conservation Service will, on an annual basis, determine how each can best contribute in carrying out an accelerated land treatment program in the watershed.

The total cost of installing forest land treatment measures is estimated to be $86,500. Technical assistance to forest landowners for the installation of these measures will amount to $39,000. This expenditure will be shared equally by the State and Federal government. The remaining $47,500 includes $8,400 to be contributed by the State for tree seedlings furnished the landowners. The balance of $39,100 is the installation cost to the landowners.

The Titusville City Council will enter into agreement with the Pennsylvania Department of Highways and Supervisors of Sparta, Athens, and Oil Creek Townships, for the abandonment, relocation or flooding easements of those roads affected by structures PA-641, PA-643, PA-645, and PA-646.

The Titusville City Council will provide funds for carrying out its responsibilities from its general funds or taxation. It is expected that local subdivisions and interested individuals and businesses will contribute to this cost.

Financial and other assistance to be furnished by the Soil Conservation Service in carrying out the watershed work plan is contingent on the availability of funds for this purpose.

PROVISIONS FOR OPERATION AND MAINTENANCE

Land Treatment

Land treatment measures for both open land and forest land will be maintained by the landowners or operators of the land on which these measures are installed. Maintenance and treatment measures will be promoted and encouraged through the Soil and Water Conservation District program with technical assistance furnished by the Soil Conservation Service and other federal, state, and local organizations.

The forest land treatment measures will be operated and maintained by the landowners with technical assistance provided by the Pennsylvania Department of Forests and Waters in cooperation with the U. S. Forest Service under the going Cooperative Forest Management Program. Other federal-state cooperative forestry programs will continue after the installation period.

Structural Measures

Land treatment measures will be maintained by the landowners and operators under agreement with the Crawford County Soil and Water Conservation District.

The Titusville City Council will be responsible for operation and maintenance of structures PA-641, PA-642, PA-643, PA-644, PA-645, and PA-646 at an estimated annual cost of $3,300.

All structural measures should be inspected after every major storm and will be inspected at least once a year. Representatives of the sponsoring local organizations responsible for operation and maintenance and the Soil Conservation Service will jointly make the required annual inspection in accordance with the Operation and Maintenance agreement. A report including recommendations for repairs, improvements and replacements will be prepared and filed for each inspection. A report will also be prepared for the completed maintenance.

The structural works of improvement will be operated in such a manner that they will serve the purpose, both as to function and time, for which they are installed.

The maintenance will consist of, but not be limited to, the following:

1. Remove and burn debris.

2. Refill, smooth and vegetate rilling on embankments, spillways, and drainageways.

3. Realign disposal channels.

4. Repair damaged riprap, concrete or other works.

5. Repair fences and gates.

6. Maintain good sod covers.

Specific maintenance agreements will be entered into prior to the execution of the project agreement for works of improvement.

TABLE 1 - ESTIMATED PROJECT INSTALLATION COST

Oil Creek Watershed, Pennsylvania

Installation Cost Item	To Be Applied Unit	Non-Federal Land Number	Estimated Cost 1/ P.L.566 Dollars	Other Dollars	Total Dollars
Land Treatment					
Soil Conservation Service					
Cropland	acre	3,800	-	148,590	148,590
Grassland	acre	4,900	-	327,200	327,200
Wildlife-Recreation	acre	1,570	-	115,550	115,550
Technical Assistance			88,000	45,500	133,500
SCS Subtotal			88,000	636,840	724,840
Forest Service					
Woodland	acre	2,315	-	47,500	47,500
Technical Assistance			19,500	19,500	39,000
FS Subtotal			19,500	67,000	86,500
TOTAL LAND TREATMENT (under Other Dollars)			107,500	703,840	811,340
Structural Measures					
Soil Conservation Service					
Floodwater Retarding Structure	each	6	1,789,755	-	1,789,755
SCS Subtotal - Construction			1,789,755	-	1,789,755
Installation Services					
Soil Conservation Service					
Engineering Services			242,597	-	242,597
Other			101,728	-	101,728
SCS Subtotal - Installation Services			344,325	-	344,325
Other Costs					
Land Easements & R/W			-	191,850	191,850
Administration of Contracts			-	26,500	26,500
Subtotal - Other				218,350	218,350
TOTAL STRUCTURAL MEASURES			2,134,080	218,350	2,352,430
TOTAL PROJECT			2,241,580	922,190	3,163,770
SUMMARY					
Subtotal - SCS			2,222,080	855,190	3,077,270
Subtotal - FS			19,500	67,000	86,500
TOTAL PROJECT			2,241,580	922,190	3,163,770

1/ Price Base - 1964

April 1965

TABLE 3 - STRUCTURE DATA
FLOODWATER RETARDING STRUCTURES AND WATER SUPPLY RESERVOIRS
Oil Creek Watershed, Pennsylvania

Item	Unit	Structure Number PA-641	PA-642	PA-643	PA-644	PA-645	PA-646	Total
Drainage Area	sq.mi.	9.04	7.29	8.90	8.70	34.90	3.41	72.24
Storage Capacity								
Sediment	ac.ft.	123	40	62	75	145	46	491
Floodwater	ac.ft.	1300	1092	1101	1460	5000	546	10,499
Total	ac.ft.	1423	1132	1163	1535	5145	592	10,990
Between High & Low Stages	ac.ft.	482	311	570	-	-	-	1,363
Surface Area								
Sediment	acres	15	8	7	8	30	5	73
Floodwater Pool	acres	120	100	112	125	370	30	832
Volume of Fill	cu.yd.	203,000	490,000	60,000	168,000	310,000	185,000	1,416,000
Elevation Top of Dam	feet	1367.5	12,125	1419	1502	1324.5	1295	
Maximum Height of Dam	feet	43	36	45	50	45	60	
Emergency Spillway								
Crest Elevation	feet	1357	1417	1407	1493.5	1312.0	1285.5	
Bottom Width	feet	370	300	150	250	600	200	
Type		sod	sod	rock	sod	sod	sod	
Percent chance of Use		1.0	1.0	1.0	1.0	1.0	1.0	
Aver. Curve No. (Cond. II)		76	76	71	71	76	71	
Emergency Spillway Hydrograph								
Storm Rainfall (6-hr.)	inch	9.0	9.0	9.0	9.0	9.0	9.0	
Storm Runoff	inch	8.04	8.04	7.54	7.54	7.15	7.54	
Velocity of Flow	ft./sec.	8.6	8.3	9.2	8.0	8.9	8.5	
Discharge Rate	c.f.s.	7770	5300	4100	4300	13,500	4200	
Max. Water Surface Elevation	feet	1,362.4	1,420.8	1,412.7	1,497.3	1,317.9	1,289.6	
Freeboard Hydrograph								
Storm Rainfall (6-hr.)	inch	25.0	25.0	25.0	25.0	25.0	25.0	
Storm Runoff	inch	21.56	21.56	20.69	20.69	19.10	20.69	
Velocity of Flow	ft./sec.	13.1	12.2	13.9	12.7	14.5	13.3	
Discharge Rate	c.f.s.	28,100	18,300	15,700	17,200	59,500	16,600	
Max. Water Surface Elevation	feet	1,367.5	1,424.8	1,418.6	1,502.0	1,324.5	1,294.9	
Principal Spillway								
Capacity - Low Stage	c.f.s.	136	110	150	190	959	76	
Capacity - High Stage	c.f.s.	230	223	232	-	-	-	
Capacity Equivalent								
Sediment Volume	inch	0.255	0.104	0.13	0.16	0.078	0.253	
Detention Volume	inch	2.70	2.81	2.32	3.14	2.69	3.00	
Spillway Storage	inch	3.16	2.52	4.08	2.94	3.15	1.74	
Class of Structure		C	C	C	C	C	C	

April 1965

TABLE 4 - ANNUAL COST

Oil Creek Watershed, Pennsylvania

(Dollars) 1/

Evaluation Unit	Amortization of Installation Cost 2/	Operation and Maintenance Cost 3/	Total
PA-641, PA-642,) PA-643, PA-644,) PA-645, PA-646)	77,066	3,300	80,366
TOTAL	77,066	3,300	80,366

1/ Price Base - 1964

2/ Amortized at 3-1/8 percent for 100 years.

3/ Long term price level as projected by Agricultural Research Service Price Projection, September 1957.

April 1965

TABLE 5 - ESTIMATED AVERAGE ANNUAL FLOOD DAMAGE REDUCTION BENEFITS

Oil Creek Watershed, Pennsylvania

(Dollars) 1/

Item	Estimated Average Annual Damage Without Project	Estimated Average Annual Damage With Project	Damage Reduction Benefit
Floodwater			
Non-Agricultural			
Residential	12,654	1,296	11,358
Commercial	10,806	149	10,657
Industrial	147,008	780	146,228
Park	1,788	39	1,749
Bridge & Roads	1,054	99	955
Subtotal	173,310	2,363	170,947
Indirect (20%)	34,662	473	34,189
Agricultural			
Crop & Pasture	965	219	746
Other	786	186	600
Subtotal	1,751	405	1,346
Indirect (10%)	175	40	135
Sediment			
Bedload	304	27	277
Subtotal	304	27	277
Indirect (10%)	31	3	28
Indirect Total	34,868	516	34,352
Total	210,233	3,311	206,922

1/ Price Base - Long Term.

April 1965

TABLE 6 - COMPARISON OF BENEFITS AND COSTS FOR STRUCTURAL MEASURES

Oil Creek Watershed, Pennsylvania

(Dollars) 1/

Evaluation Unit	Average Annual Benefits			Average Annual Cost	Benefit Cost Ratio
	Flood Prevention Damage Reduction	Other	Total		
PA-641) PA-642) PA-643) PA-644) PA-645) PA-646	199,990	9,100	209,090	80,366	2.6 to 1.0
TOTAL	199,990 2/	9,100 3/	209,090	80,366	2.6 to 1.0

1/ Price Base - 1964, for costs, long term projected prices for benefits and operation and maintenance.

2/ In addition it is estimated that land treatment measures will provide flood damage reduction benefits of $6,933 annually.

3/ Area Redevelopment Benefits - for labor that in absence of project would not be utilized.

April 1965

INVESTIGATIONS AND ANALYSES

Hydrologic

The watershed was analyzed using procedures outlined in the Soil Conservation Service National Engineering Handbook, Hydrology Section, and Supplement A to the Hydrology Section. The percent chance of occurrence of peak flood discharge was obtained from data supplied by a U. S. Geologic Survey recording gauge on Oil Creek at Rouseville. The Rouseville recording gauge was installed June 9, 1941. A non-recording record was compiled at Rouseville from June 1, 1932 to the time the recording gauge was installed. From 1910 to 1932, a non-recording record was compiled at a site one and one-half miles downstream from the present gauge location.

The January 22, 1959 key flood hydrograph was routed through all of the damage centers and to the Rouseville gauge as a check on various parameters used. The stage of the routed key flood was also checked by several high water marks at the damage centers. Synthetic hydrographs were routed for various magnitude storms by a digital computer on a program developed by the Washington Engineering staff. This flood routing utilized the convex flood routing procedure.

Rainfall-runoff relationships were determined from a study of the soils and soil cover and checked for storm runoff at the Rouseville gauge. A tabulation of the soil type and hydrologic characteristics were supplied by the work unit conservationist. The U. S. Forest Service supplied the hydrologic data on forest land and the forest land cover complex numbers. Information was collected in a series of field plots, selected systematically, where measurements of litter, humus, soil type, and other hydrologic factors were recorded and analyzed.

The procedures outlined in Engineering and Watershed Planning Memorandum 34, Hydrology 3, were used to evaluate the effects of future land treatment.

The above analysis was repeated assuming the proposed works of improvement installed to determine their effect on flood frequency and magnitude.

Design Hydrology

The floodwater storage requirements were determined by use of Soil Conservation Service Technical Release #10, and rainfall-frequency data obtained from U. S. Department of Commerce, Weather Bureau Technical Paper 40. A review of the Oil Creek stream gauge records and dates of peak flood discharges reveals that damaging floods are most likely to occur during the winter and early spring and are associated with snow-melt. Since the intense storms of Technical Paper 40 tend to occur during the summer months, floods produced by winter rains and snow-melt had to be considered in designing the floodwater storage requirement. The procedure for designing floodwater

storage and structure release rates as recommended by the Engineering and Watershed Planning Unit hydrologists for northern Pennsylvania was followed. These floodwater storage and structure releases were part of the input data used by the computer for flood routing controlled storms.

Analysis of the flood routing results indicates that the structures so designed would have controlled the key flood.

The emergency spillways were designed to safely pass the hydrograph for Class C structures produced by a rainfall of nine inches falling on previously saturated soil moisture condition. The top of dam is established by a freeboard hydrograph which must be passed through the spillways of the structure. The freeboard rainfall for Class C structures is 25 inches falling on average soil moisture conditions.

Hydraulic

Twelve evaluation reaches were used to determine flood damages in the watershed. Flood damage and stream characteristics were considered in selection and rating of these various reaches. Stage versus discharge curves were prepared for the reference section of each reach. Stage versus discharge at Titusville was determined by computing the water surface profile using the step method as outlined in Supplement A to the Hydrology Guide. Stage versus discharge at Hydetown and Mystic Park was computed by use of Manning's equation for open channel flow. Church Run at Titusville required the use of Bernoulli's Theorem for Hydraulic and Energy Gradient for in-bank flow and Manning's equation for out-of-bank flow.

The principal spillway release for the structures was determined by channel bank capacity below the structures and by routing the uncontrolled drainage area hydrograph through damage centers. The channel capacity is large enough to permit maximum reservoir release rates on PA-644, PA-645, and PA-646. Structures PA-641, PA-642 and PA-643 must use a two-stage riser configuration.

Engineering

The eight dam sites considered were selected on the basis of a study of the U. S. Geologic Survey topographic maps of the watershed and a field study of specific site conditions.

The procedure for the preliminary design of the dams was as follows:

1. From a plane table-alidade survey, a 5-foot contour interval topographic map of each site was prepared to a scale of 100 to 300 feet to the inch, depending on the size of the site. All surveys were based upon the mean sea level datum.

2. The stage area and stage-storage relationships were developed from each map for the storage basin created by the proposed dam.

3. From the stage-storage relationship the crest of the low stage inlet of the principal spillway was set at the sediment pool elevation.

4. The floodwater detention and principal spillway requirements were determined by the hydrologist.

5. The elevation of the crest of the emergency spillway was determined by combining the storage computed in step 4 to the total sediment storage and applying this storage to the stage-storage relationship.

6. The emergency spillway hydrograph was routed through the structure using emergency spillways of various widths, by the parabolic method described in the Soil Conservation Service Technical Release 2, Design Section. From these trial routings the emergency spillway dimensions were selected, considering the following items.

   a. Permissible velocity of flow through the spillway.

   b. Minimum total cost of the project.

7. The top of dam elevation was determined by flood routing the freeboard hydrograph through the structure by method 2, described in Section 5.8, Soil Conservation Service National Engineering Handbook, Hydraulics.

8. The preliminary design quantities used for estimating construction costs were determined for 11 items: clearing, clear and grub, fill (earth and rock), excavation (common and rock), pipe, concrete, filter and drainage material, rock riprap, fencing and seeding.

All the proposed dams were classified "C" structures according to Engineering Memorandum, SCS-27.

Preliminary designs are subject to change based on detailed geology and soil mechanics information which will be obtained prior to final design.

The final design for each project will be submitted to the Water and Power Resources Board of the Pennsylvania Department of Forests and Waters for approval.

The following information is pertinent to the design and cost of each structure:

PA-641

PA-641 is designed with three-to-one upstream and three-to-one downstream side slopes. A combination of a partial cutoff core and toe drains is planned to control seepage and uplift pressures.

PA-642

PA-642 is designed with four-to-one upstream and downstream side slopes to assure structural stability. Relatively deep toe drains are planned to control uplift pressures. The orgonic alluvial material and topsoil will be stripped from the foundation of the dam.

PA-643

PA-643 is designed with three-to-one upstream and downstream side slopes. A partial cutoff core and toe drains are planned to control seepage and uplift pressures.

PA-644

PA-644 is designed with three-to-one upstream and downstream side slopes with berms for structural stability. A partial cutoff core and blanket drains are planned to control seepage and uplift pressures.

PA-645

PA-645 is designed with three-to-one upstream and downstream side slopes. The preliminary cost estimate for this dam provides for extensive foundation excavation for structural stability and for the installation of toe drains.

PA-646

PA-646 is designed with three-to-one upstream and two-to-one downstream side slopes with berms for structural stability. A combination of a partial cutoff core and toe drains is planned to control seepage and uplift pressures.

Geology

A reconnaissance was made of land subject to flooding for damages caused by streambank erosion, swamping, flood plain scour and infertile overwash. Damages from these sources occurred to residential areas, roads, and nonagricultural land. Monetary benefits were claimed on an individual case basis. Sediment damage to homes and businesses was

included with floodwater damage due to the difficulty in separating the two. A detailed study was made of sedimentation by bedload deposition within the City of Titusville.

Sediment storage requirements for the proposed floodwater dams were computed by procedures outlined in the Geology section of the Watershed Planning Guide. Factors taken into consideration were land use, future urban growth, sheet erosion, channel erosion, delivery rate to the structure and trap efficiency of the reservoir. Sheet erosion rates were computed from a special study comparing Universal Soil Loss and Musgrave Probable Soil Loss equations based on the same parameters. This basic data was obtained from soil maps, air photographs, and field measurements. Sediment storage will contain the expected sediment accumulation at the reservoirs for a hundred year period.

The field procedures used in the preliminary geologic investigations of the sites included the use of a portable refraction seismograph, resistivity apparatus, manual sampling and exploration tools, and soil testing equipment. The findings were correlated with published geologic data from this region. Features such as bedrock profiles, soil types and logs, and groundwater levels were plotted and their relationship with the proposed works of improvement evaluated. A plan and cost estimate of detailed geologic site investigations were made for each of the sites.

The preliminary geologic investigation of the proposed sites revealed the following conditions:

PA-641

This site is formed by glacial till assigned to the Kent ground moraine overlying sandstone and shales of the Devonian-Riceville Formation age and the Mississippian-Pocono group. These materials normally provide a strong, slowly permeable foundation. Some permeability problems are suggested by fluvioglacial deposits of sand and gravel located on the abutments. High permeability areas within the glacial tills are also suggested by side hill springs. These areas, as well as about ten feet of fine to coarse alluvium, were considered in the preliminary design. Ample borrow for the proposed dam is available within the site, the majority of which will be from the emergency spillway excavation. Sediment storage for the site is estimated to be 123.1 acre feet with 62.6 acre feet allocated to the sediment pool and the remainder to the flood pool.

PA-642

Site PA-642 is formed by a moderately deep glacial valley cut through rocks of the Pocono group to the approximate contact with Riceville shale. Soils grading SM to GM from the tills of the Kent moraine occur on both abutments to a moderate depth. The flood plain at the site is very broad and is formed from alluvium underlain by outwash. Borings indicate the

presence of soft, compressible layers within the outwash presenting a high consolidation potential as compared with the relatively strong abutments. Tests performed in the outwash materials show a rapid permeability in sand and gravel zones. Adequate borrow for the proposed dam is available within the site. Sediment storage for the site is estimated to be 40.3 acre feet with 20.7 acre feet allocated to the sediment pool and the balance to the flood pool.

PA-643

The site was formed by a narrow stream valley cutting through the Pocono sandstones and shales to form a narrow, very steep sided valley. The abutments are capped with silty sands and gravels assigned to the Kent moraine. A kame terrace, located on the right abutment, feathers out on top of the morainal deposits to the south. The kame extends for several miles to the west and would probably provide a source of leakage at higher reservoir elevations. Less than ten feet of coarse alluvium overlies rock on the narrow valley floor. Broken and weathered sandstone and shale will probably allow moderate leakage outcrops on the steep left abutment.

The emergency spillway on the right abutment will provide the basic borrow source for the proposed dam. Some minor rock excavation will be included with the borrow soils which grade from clean fluvio-glacial sands and gravels to till originated soil mixtures with a great percentage of fine grained materials. Sediment storage for the site is estimated to be 61.8 acre feet with 30.9 acre feet allocated to the sediment pool and the remainder to the flood pool.

PA-644

This site was developed by glacial deposition of the Kent ground moraine over sandstones, siltstones, and shales of the Pocono group. This was downcut over 100 feet by glacial meltwater to form a narrow valley. This valley was then partially filled by outwash material. Geophysical studies indicate that outwash derived materials are both fine grained (possible Lucustrine) materials as well as sands and gravels. This gives possibilities of a difference in consolidation rates between strong rock abutments and weaker, possibly discontinuous, fine grained sediments. Coarse grained sediments occurring in the outwash will also have a high permeability rate. Some rock is anticipated in the spillway excavation. Borrow sources will be from the morainal deposits located in the emergency spillway and right abutment upstream from the fill. These soils will be variable mixtures of clay, silt, sand and gravel. Sediment storage for the site is estimated to be 75.0 acre feet with 39.5 acre feet allocated to the sediment pool and the balance to the flood pool.

PA-645

This site is made of a variety of glacial deposits overlying sandstone and shales of both the Riceville shale and the Pocono group. The left abutment is composed of glacial drifts of the Kent ground moraine over rock. The balance of the site consists of a moderately-wide outwash buried valley. In the right abutment a kame terrace of clean sands and gravels overlies or overlaps lucustrine lake deposits of (ML and CL) silts and clays. On the flood plain, electrical resistance survey indicates fine grained, possibly lucustrine deposits, interbedded with coarser grained sediments. This presents possibilities of high permeability rates in the coarse grained sediments. A difference in the consolidation potential exists between the strong left abutment and the weaker fluvio-glacial deposits and between the different types of outwash sediments. The kame terraces on the right abutment also present possibilities of a highly permeable zone. The spillway on the right abutment would provide a variety of soils for the borrow material of the proposed structure. Sediment storage for the site is estimated to be 144.6 acre feet with 74.6 acre feet allocated to the sediment pool and the balance to the flood pool. Sediment deposition in Lake Canadohta was taken into consideration in the sediment routing for the structure.

PA-646

The site is formed by Illinois glacial tills overlying sandstones, siltstones, and shales of the Pocono group. The left abutment is relatively steep and the stream located at the base of the left abutment has cut down through the drift into the rock. The right abutment has a deeper drift covering and is less steep. Terrace remnants of silty soils are located at the base of the right abutment. There is about five feet of coarse alluvium with a two-foot silt cap on the narrow flood plain. Glacial tills are generally strong and slowly permeable but high permeability rates are anticipated in the coarse alluvium. The rock outcrop is moderately broken and weathered, suggesting a moderate permeability rate. The major portion of the borrow will be available from the emergency spillway excavation and grades from a ML-CL with sand and gravel to well-graded SM. Some minor rock excavation is anticipated in the emergency spillway excavation. A line of springs was noted emerging at the base of the right abutment. Sediment storage for the proposed structure is 46.1 acre feet with 23.3 acre feet allocated to the sediment pool and the balance to the flood pool.

Economics

The basic information on damages was obtained in the field from personal interviews with property owners and was recorded on flood damage schedules. This information was related to the flood of January 22, 1959. The sponsoring organizations cooperated in contacting all of the owners or operators of commercial and industrial property and approximately 40 percent of the residential property owners that were affected by Oil Creek and its tributaries. Damages for stages above and below the 1959 flood level were appraised in one-foot increments.

The damage estimates were tabulated by stages and converted to long-term prices using Agricultural Research Service Price and Cost Projections, September 1957.

All costs to be incurred during the seven-year installation period of the project were based on the 1964 price level. Operation and maintenance costs have been adjusted to long-term values.

Floodwater damages and benefits were computed using the frequency method as described in Chapter 3, page 2 of the Economic Guide, Soil Conservation Service. Separate damage-frequency analyses were developed for each reach using the stage-frequency data provided by the hydrologic study. Damage and benefits affecting residential, commercial, and industrial property were computed under (1) condition without the project, (2) conditions after the installation of the proposed land treatment, and (3) conditions with all measures installed.

Since the structures are all located above the common damage center of Titusville, one evaluation unit was used for flood prevention. This evaluation study includes all floods up to the 100-year frequency.

Sediment benefits were computed for the sedimentation reduction of the bedload deposition in Titusville. These damages were computed on cost of removal data supplied by the city officials. Estimated annual damages and benefits were evaluated by the frequency method.

Agricultural damage in the watershed, being less than one percent of the total, does not constitute a substantial portion of the average annual damage. Because of this, a detailed study of the agricultural damage was not made. The estimate of agricultural damage is based on the actual acres of cropland and pasture that were inundated by the key storm. Damage values and benefits obtained were based on information from watersheds where detailed studies have been made.

Redevelopment benefits were computed for employment that would not be utilized in the absence of the project. These benefits were predicated on the use of local unskilled labor during construction of the proposed project. These costs were computed at local prices and amortized over the life of the project. The redevelopment benefits

from employment in the operation and maintenance phase of the project were also considered as project benefits. These benefits were limited to a twenty-year period and amortized over the life of the project at 3 1/8 percent interest.

Land Treatment

The land treatment program was developed by the Soil and Water Conservation District, the Soil Conservation Service, the U. S. Forest Service, the Pennsylvania Department of Forests and Waters, the Agricultural Stabilization and Conservation Service Committee, and the Agricultural Extension Service.

Basic data available to this committee included records of conservation treatment by landowners in the watershed and land use trends as indicated by the Conservation Needs Inventory. Records of the Soil and Water Conservation District and the Agricultural Stabilization and Conservation Service were also made available for the study.

The following table indicates present land use and estimates future land use (1975) with the program installed:

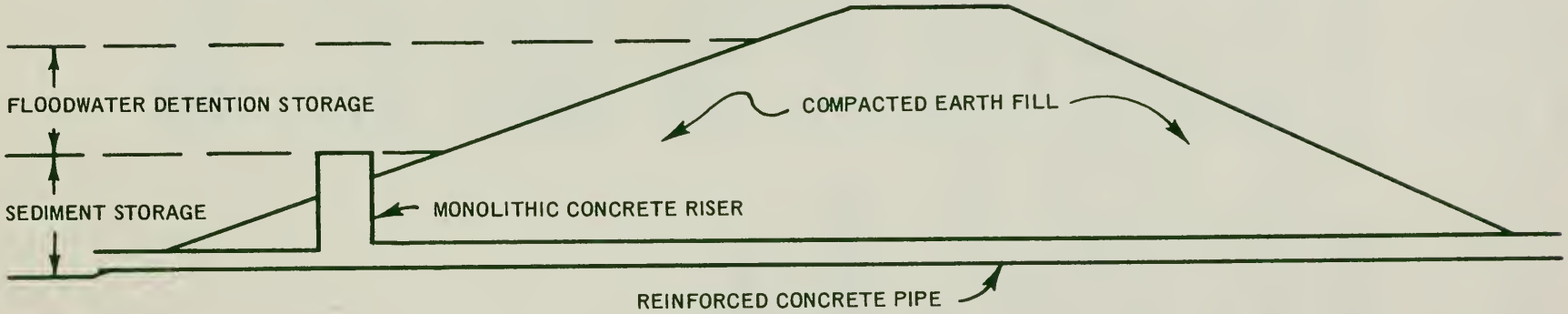
Land Use Groups	Present Land Use Acres	Future Land Use Acres
Cropland	16,800	14,530
Pasture	16,800	14,430
Forest	61,600	66,650
Idle	11,200	8,870
Other	5,600	7,520
Total	112,000	112,000

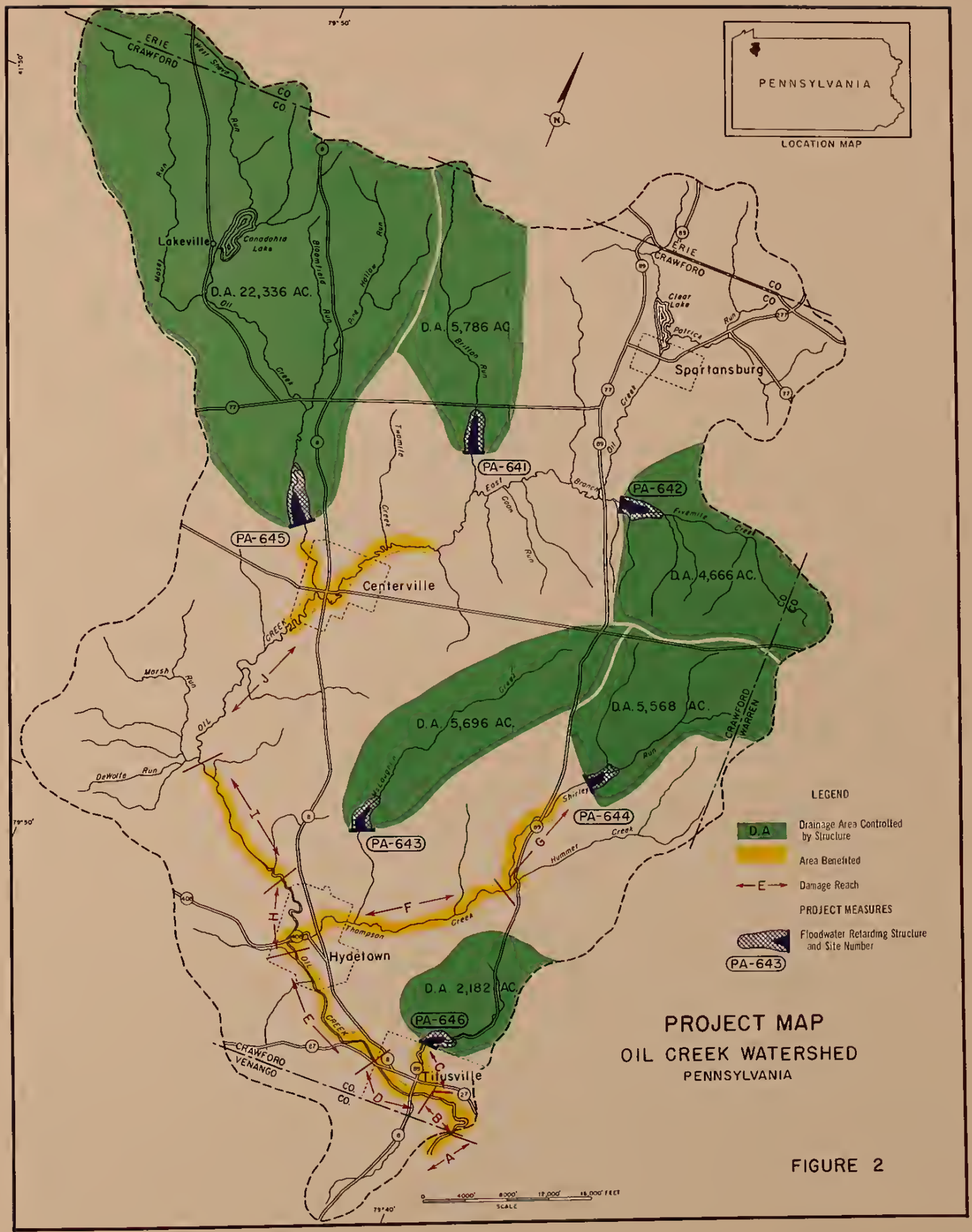
GLOSSARY OF TERMS

Average Annual Cost	Total installation cost amortized over a 100-year period at 3 1/8 percent interest plus annual operations and maintenance costs.
Average Annual Damage	The summation of all expected flood damage in 100 years divided by 100.
Easements and Rights-of-Way Cost	Cost to acquire land or obtain easements on land, relocate or alter existing roads, utilities, etc., necessary for the installation of the structure.
Floodwater Retarding Structure	A dam built to contain excess runoff water and regulate its release.
Flood Detention Pool	A volume of space incorporated in a reservoir to store excess runoff water.
Floodwater Damage	Direct accountable damage to property caused by flooding.
Flood Prevention Benefits	Reduction of floodwater and sediment damages expressed in monetary terms.
Frequency of Flooding	An estimate of how often various flood magnitudes will occur. Example: 50-year frequency--once in 50 years or twice in 100 years.
Indirect Damage	Non-enumerated damage related to flooding. Example: Detours caused by road or bridge washout, loss of wages caused by inability to travel to job, spoilage of food caused by electric utility failure, etc.
Key Flood	A flood about which much information is available. Stage damage relationships are keyed to the stage of this flood.
Other Costs	Costs other than Public Law 566 costs.
P.L. 566 Costs	Costs which the Federal Government is authorized to bear under authority of Public Law 566.

FIGURE 1

SCHEMATIC VIEW OF TYPICAL STRUCTURE SECTION




PENNSYLVANIA
LOCATION MAP
ERIE
CRAWFORD
CO
CO
Lakeville
Canadohta Lake
D.A. 22,336 AC.
D.A. 5,786 AC.
Spartansburg
Clear Lake
PA-641
PA-642
PA-645
Centerville
D.A. 4,666 AC.
D.A. 5,696 AC.
D.A. 5,568 AC.
PA-643
PA-644
Hydetown
D.A. 2,182 AC.
PA-646
Titusville
CRAWFORD
VENANGO
CO.
CRAWFORD
WARREN
LEGEND
D.A
Drainage Area Controlled by Structure
Area Benefited
E
Damage Reach
PROJECT MEASURES
Floodwater Retarding Structure and Site Number
PA-643
PROJECT MAP
OIL CREEK WATERSHED
PENNSYLVANIA
FIGURE 2

LEGEND

100–Year Flood High Water Line

Controlled 100–Year Flood High Water Line

January 1959 High Water Line

0 1000' 2000' 3000' 4000'

FIGURE 3

FLOOD FREQUENCY MAP

OIL CREEK WATERSHED

PENNSYLVANIA

USDA-SCS-HYATTSVILLE, MD. 1965